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(54) Title: PLANARIZING ELEMENT FOR THERMAL PRINTING OF COLOR FILTER

(57) Abstract: A planarizing element is described for use in a thermal imaging process. The planarizing element includes a support; a planarizing layer comprising a crosslinkable binder having a weight average molecular weight of about 20,000 to about 110,000.

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TITLE

PLANARIZING ELEMENT FOR THERMAL PRINTING OF COLOR FILTER

## FILTERS

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FIELD OF THE INVENTION

This invention relates to improved products and processes for effecting laser-induced thermal transfer imaging in the formation of color filters. The invention is of particular utility in the formation of color filters in high resolution liquid crystal displays.

10

BACKGROUND OF THE INVENTION

Liquid crystal display (LCD) devices have become increasingly important in displays that require very low consumption of electrical power or where the environment dictates a lightweight, planar, flat surface. For example, LCDs are used in display devices such as wristwatches, pocket and personal computers, flat panel television displays and aircraft cockpit displays. When there is a need to incorporate a color display capability into such display devices, a component called a color filter is used. For the device to have color capability, each LCD pixel is aligned with a color area, typically red, green, or blue, of a color filter array. Depending upon the image to be displayed, one or more of the pixel electrodes is energized during display operation to allow full light, no light, or partial light to be transmitted through the color filter area associated with that pixel. The image perceived by a user is a blend of colors formed by the transmission of light through adjacent color filter areas.

25

A major contributor to the cost of color LCDs is the color filter. Four color filter manufacturing methods are known in the art, viz., dye gelatin, pigmented photoresist, electrodeposition and printing. The pigmented photoresist method offers the best trade-off of degradation resistance, optical properties, and flexibility along with high resolution, and is generally preferred. While conventional photolithographic materials and methods may be employed in the photoresist method, it suffers from the high cost and inconvenience associated with numerous process steps, some involving wet chemistry.

Laser-induced thermal transfer processes are well-known in applications such as color proofing and lithography and have been described in, for example, Baldock, U.K. Patent 2,083,726; DeBoer, U.S. Patent 4,942,141; Kellogg, U.S. Patent 5,019,549; Evans, U.S.

thereto before, during and after the image transfer process is effected, forming a single cohesive, homogeneous mass. It is found that the physical properties of the binder have significant effect on the properties of the transferred image. In particular, it has been found in the practice of the art that binders characterized by glass transition temperatures near or below room temperature provide good toughness and durability with superior adhesive properties, but often at the expense of resolution. On the other hand, binders characterized by glass transition temperatures well above room temperature provide superior resolution but at the expense of toughness, durability, and adhesion. Practical application of laser-induced thermal image transfer to high resolution applications such as color filter formation requires toughness and adhesion sufficient to permit survival of the transferred image during the remainder of the manufacturing process. The resolution requirements for the color filter application are extremely demanding, and little trade-off can be made while preserving utility in the application.

Aqueous blends of colloiddally dispersed polymers for use in making organic coatings which are hard and ductile at ambient temperature and which remain stiff and elastic at elevated temperature are disclosed in Mazur et al, U.S. Patent 6,020,416. The combination of properties is attributed to the use of blends of high molecular weight polymers differing in glass transition temperature.

A need exists for stable crosslinked pigmented images on a substrate wherein the surface of the image away from the substrate is an extremely smooth surface.

#### SUMMARY OF THE INVENTION

Improved products and processes for laser induced thermal imaging are disclosed herein.

In a first aspect, this invention provides a planarizing element comprising a planarizing layer, wherein the planarizing layer comprises a crosslinkable binder, and wherein the crosslinkable binder has a weight average molecular weight of about 20,000 to about 110,000. More typically, the crosslinkable binder has a weight average molecular weight of about 30,000 to about 100,000, and still more typically about 50,000 to about 85,000.

In a second aspect, the invention provides a method for making a color image comprising: (1) imagewise exposing to laser radiation a

substrate; and (3) applying a planarizing element comprising a support and a planarizing layer to the colorant-containing image, and removing the support, wherein the planarizing layer is adjacent the colorant-containing image, and wherein the planarizing layer comprises a crosslinkable binder having a weight average molecular weight of about 20,000 to about 110,000. The permanent substrate may be glass or treated glass. Alternately, the permanent substrate may be a rigid plastic, e.g. polycarbonate, or treated rigid plastic. More typically, the crosslinkable binder has a weight average molecular weight of about 30,000 to about 100,000, and still more typically about 50,000 to about 85,000.

In a fourth aspect, the invention provides a color liquid crystal display comprising a color filter, wherein the color filter is prepared using a thermal imaging process, and a planarizing element comprising a planarizing layer having a crosslinkable binder having a weight average molecular weight of about 20,000 to about 110,000. More typically, the crosslinkable binder has a weight average molecular weight of about 30,000 to about 100,000, and still more typically about 50,000 to about 85,000.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic cross sectional view of an LCD display incorporating the color filter of this invention.

Figure 2 is a simplified schematic diagram of an assemblage comprising a donor element and a receiver element for use in the thermally imaging process of the invention.

Figure 3 illustrates the receiver element of Figure 2 after exposure and separation from the donor element, wherein the receiver element comprises a receiver support, which may be glass, and carries a color image transferred from the thermally imageable layer of the donor element.

Figures 4 illustrates the receiver element of Figure 2 after exposure and separation from the donor element, wherein the receiver element carries a color image transferred from the thermally imageable layer of the donor element, and the transfer of said color image to a permanent substrate.

Figure 5a is the layout of a drum type thermal imager.

Figure 5b is the layout of a flat bed thermal imager.

Figure 6 shows the orientation of color stripes to the peel direction.

molecular weight of about 30,000 to about 100,000, and still more typically about 50,000 to about 85,000. The binders may be film forming and coatable from solution or from a dispersion. Binders having glass transition temperatures below about 110°C are preferred.

5           Process steps used to convert color filters into LCD panels often involve contact of the color filter with organic solvents such as N-methylpyrrolidinone,  $\gamma$ -butyrolactone, acetone, isopropanol, etc. Since these solvents swell, or even dissolve, the low molecular weight binder resins used in the planarizing layer (40), some form of crosslinking  
10           capability must be provided.

          Some suitable pairs of functional groups for such crosslinking reactions include: hydroxyl and isocyanate; hydroxyl and carboxyl; hydroxyl and melamine-formaldehyde; carboxyl and melamine-formaldehyde; carboxyl and amine; carboxyl and epoxy, epoxy and amine;  
15           and carboxylic anhydride and amine. The pairs of crosslinking functional groups can be utilized in several ways. One crosslinking functional group can be incorporated into the binder polymer backbone, and the other added as a polyfunctional low molecular weight crosslinking agent. One crosslinking functional group can be incorporated into the binder polymer  
20           backbone, and the other incorporated into a different binder polymer backbone. Both of the crosslinking functional groups can be incorporated into the same binder polymer backbone.

          Another crosslinking reaction involves one or more of the polymeric binders having pendant groups that are capable of undergoing free-radical  
25           induced or cationic crosslinking reactions. Pendant groups which are capable of undergoing free-radical induced crosslinking reactions are generally those which contain sites of ethylenic unsaturation, such as mono- and poly-unsaturated alkyl groups; acrylic and methacrylic acids and esters. In some cases, the pendant crosslinking group can be  
30           photosensitive, as is the case with pendant cinnamoyl or N-alkyl stilbazolium groups. Pendant groups which are capable of undergoing cationic crosslinking reactions include substituted and unsubstituted epoxide and aziridine groups.

          Additional components may include the coating aids, UV stabilizers,  
35           UV-filters, UV absorbers, small molecule crosslinking aids, plasticizers, flow additives, adhesion promoters, antistatic agents, surfactants, and others which are known for use in the formulation of films, with the proviso

Some examples of other suitable materials are transition metal elements and metallic elements of Groups 13, 14, 15 and 16, their alloys with each other, and their alloys with the elements of Groups 1 and 2, which have less adhesion to the thermally imageable layer (12), or may be  
5 treated to have less adhesion, than the adhesion of the thermally imageable layer (12) to the receiving surface of the substrate (24) and absorb the wavelength of the laser. The IUPAC numbering system is used throughout, where the groups are numbered from left to right as 1-18 (CRC Handbook of Chemistry and Physics, 81<sup>st</sup> Edition, 2000). Tungsten  
10 (W) is an example of a suitable transition metal.

Carbon, a Group 14, nonmetallic element, may also be used.

Nickel, aluminum, chromium and nickel vanadium alloys are typical metals for the heating layer (16). Chromium applied by sputtering is the most typical choice for the heating layer.

15 Alternatively, in Figure 2, the optional heating layer (16) can be an organic layer comprising an organic binder and an infrared absorber. Some examples of suitable binders include polyvinyl chloride, chlorinated polyvinyl chloride and nitrocellulose. Examples of near infrared absorbers are carbon black and infrared dyes. Polymers with higher decomposition  
20 temperatures may also be employed in fabricating organic heating layers.

The thickness of the heating layer (16) depends on the optical absorption of the metals used. The most preferred metallization is such as to give 50% optical transmission at 830 nm, with a preferred range from 25% to 60% T.

25 Although it is preferred to have a single optional heating layer, it is also possible to have more than one heating layer, and the different layers can have the same or different compositions.

The optional heating layer (16) may be applied to the base support (14) by a physical vapor deposition technique. The term "physical  
30 vapor deposition" refers to various deposition approaches carried out in vacuum. Thus, for example, physical vapor deposition includes all forms of sputtering, including ion beam sputtering, as well as all forms of vapor deposition, such as electron beam evaporation and chemical vapor deposition. A specific form of physical vapor deposition useful in the  
35 present invention is RF magnetron sputtering. Nickel may be electron beam deposited onto the base support (14). Aluminum may be applied by resistive heating. Chromium, nickel and nickel vanadium layers may be

by weight, based on the total weight of the thermally imageable layer. The weight ratio of higher  $T_g$  binder to lower  $T_g$  binder should be in the range of 60:40 to 95:5, preferably in the range of 75:25 to 92:8.

The binders suitable for use in the present invention are  
5 synthesized preferably in the form of latex dispersions, as described in Mazur et al, U.S. Patent 6,020,416, incorporated herein by reference to the entirety, and as hereinbelow exemplified. The synthesis of polymer latexes is a very well-known art in widespread commercial use.

In a preferred embodiment, one or more of the polymeric binders  
10 comprise monomer units having pendant groups that are capable of undergoing free-radical induced or cationic crosslinking reactions. Pendant groups which are capable of undergoing free-radical induced crosslinking reactions are generally those which contain sites of ethylenic unsaturation, such as mono- and polyunsaturated alkyl groups; acrylic and  
15 methacrylic acids and esters. In some cases, the pendant crosslinking group can be photosensitive, as is the case with pendant cinnamoyl or N-alkyl stilbazolium groups. Pendant groups which are capable of undergoing cationic crosslinking reactions include substituted and unsubstituted epoxide and aziridine groups.

20 Crosslinkable binders suitable for the practice of the invention can be formed by direct copolymerization of one or more ethylenically unsaturated dicarboxylic acid anhydrides, or the corresponding alkyl diesters, with one or more of the above comonomers. Suitable ethylenically unsaturated dicarboxylic acid anhydrides are, for example,  
25 maleic anhydride, itaconic acid anhydride and citraconic acid anhydride and alkyl diesters such as the diisobutyl ester of maleic anhydride. The copolymer binder containing acid anhydride functionality can be reacted with primary aliphatic or aromatic amines.

Alternately, the thermally imageable layer may comprise a low  
30 molecular weight crosslinkable binder having a number average molecular weight of about 1,500 to about 70,000.

The total binder concentration is generally in the range of about 15-50% by weight, based on the total weight of the thermally imageable layer, preferably 30-40% by weight.

35 The colorant in the thermally imageable layer may be a pigment dispersion or a non-sublimable dye. As is well known in the art, the introduction of pigments into the film compositions is most readily

surface and other components in the composition as practiced by those skilled in the art. However, one class of dispersant suitable for practicing the invention is that of the AB dispersants. The A segment of the dispersant adsorbs onto the surface of the pigment. The B segment  
5 extends into the solvent into which the pigment is dispersed. The B segment provides a barrier between pigment particles to counteract the attractive forces of the particles, and thus to prevent agglomeration. The B segment should have good compatibility with the solvent used. The AB dispersants of choice are generally described in "Use of AB Block  
10 Polymers as Dispersants for Non-aqueous Coating Systems", by H. C. Jakubauskas, *Journal of Coating Technology*, Vol. 58, No. 736, pages 71-82. Suitable AB dispersants are also disclosed in U.K. Patent 1,339,930 and U.S. Patent Nos. 3,684,771; 3,788,996; 4,070,388; 4,912,019; and 4,032,698. Other types of dispersants include graft  
15 copolymer dispersants, and random copolymer dispersants. Conventional pigment dispersing techniques, such as roll milling, media milling, ball milling, sand milling, etc., can be employed. For color filter applications, the binder polymer of the thermally imageable layer can also act as a dispersant for the pigment.

20 Other materials can be present as additives in the thermally imageable layer as long as they do not interfere with the essential function of the layer. Some examples of such additives include coating aids, plasticizers, flow additives, slip agents, antihalation agents, antistatic agents, surfactants, and others that are known for use in the formulation of  
25 coatings. However, it is preferred to minimize the amount of additional materials in this layer, as they may deleteriously affect the final product after transfer to the final support.

The thermally imageable layer generally has a thickness in the range of about 0.1 to 5 microns, preferably in the range of about 0.1 to  
30 1.5 microns. Thicknesses greater than about 5 microns are generally not preferred as they require excessive energy in order to be effectively transferred to the receiver and generally give poorly resolved images.

Although it is typical to have a single thermally imageable layer, it is also possible to have more than one thermally imageable layer, and the  
35 different layers can have the same or different compositions, as long as they all function as described above. The total thickness of the combined thermally imageable layers should be in the range given above.



Other donor elements may comprise alternate thermally imageable layer or layers on a support. Additional layers may be present depending of the specific process used for imagewise exposure and transfer of the formed images. Some suitable thermally imageable layers over which the overcoat described above may be applied are disclosed in US 5,773,188, US 5,622,795, US 5,593,808, US 5,334,573, US 5,156,938, US 5,256,506, US 5,427,847, US 5,171,650 and US 5,681,681.

#### RECEIVER ELEMENT

The receiver element, illustrated in Figure 2, comprises a receiver support (22) and an image-receiving layer (24), and optionally a cushion or release layer (not shown).

The receiver support (22) can be made of the same materials as the base support of the donor element. In addition, opaque materials, such as polyethylene terephthalate filled with a white pigment such as titanium dioxide, or synthetic paper, such as Tyvek® spunbonded polyolefin may be used as the receiver support. Typical materials for the receiver support (22) are polyethylene terephthalate and polyimide. Alternately, when the receiver element is used as the permanent substrate, the receiver support may include transparent plastic films, as described above, glass, and composites thereof. Thin glass substrates (0.5-1.0 mm thick) are typically used.

The image-receiving layer (24) may be a coating of, for example, a polycarbonate; a polyurethane; a polyester; polyvinyl chloride; styrene/acrylonitrile copolymer; poly(caprolactone); vinylacetate copolymers with ethylene and/or vinyl chloride; (meth)acrylate homopolymers (such as butyl-methacrylate) and copolymers; and mixtures thereof. This image-receiving layer may be present in any amount effective for the intended purpose. In general, good results have been obtained at coating weights of 1 to 5 g/m<sup>2</sup>. Alternately, the image receiving layer may comprise a low molecular weight crosslinkable binder having a number average molecular weight of about 1,500 to about 70,000.

In addition to the image-receiving layer, the receiver element may optionally include one or more other layers between the receiver support and the image receiving layer. One additional layer between the image-receiving layer and the support is a release layer. In the intermediate transfer process, where the receiver element is the intermediate transfer

by bringing it in contact with a roughened sheet typically under pressure and heat. The pressures used are preferably less than about 8 MPa. Optionally, heat may be applied up to about 80 to about 88°C more typically about 54°C for polycaprolactone polymers and about 94°C for poly(vinylacetate) polymers, to obtain a uniform micro-roughened surface across the image receiving layer. Alternatively, heated or chilled roughened rolls may be used to achieve the micro-roughening.

It is important that the means used for micro-roughening of the image receiving layer has uniform roughness across its surface. Typically the average roughness (Ra) as determined with a Wyko Profilometer (Wyko Model NT 3300, Veeco Metrology, Tucson, AZ)) should yield values less than about 0.6  $\mu$ .

#### PERMANENT SUBSTRATE

In the intermediate transfer process, the permanent substrate (30) used in step (3) of the process must be optically transparent. Some examples include transparent plastic films such as polyethylene terephthalate and polyimide, glass, treated glass and composites thereof, or rigid plastic such as polycarbonate or poly(4-methylpentene). Thin glass substrates (0.5-1.0 mm thick) may be typically used.

The treatment or coating on the permanent substrate (30) may be selected from the group consisting of a polycarbonate; a polyurethane; a polyester; polyvinyl chloride; styrene/acrylonitrile copolymer; poly(caprolactone); vinylacetate copolymers with ethylene and/or vinyl chloride; (meth)acrylate homopolymers (such as butyl-methacrylate) and copolymers; and mixtures thereof. This layer may be present in any amount effective for the intended purpose. In general, good results have been obtained at coating weights of 1 to 5 g/m<sup>2</sup>.

In the direct transfer process, the receiver element in step (2) is the permanent substrate (30). The receiver support (22) and an optional image-receiving layer (24) comprise the materials described above for the permanent substrate (30) and the treatment or coating thereon.

It may also be advantageous to employ a substrate that incorporates a pre-formed black mask pattern. Typically, a pre-formed black mask is used in the case of rigid glass or plastic substrates, and also can be employed with flexible permanent substrates or even with flexible intermediate receiver supports. The black mask, which serves to delineate the colored (e.g. RGB) pixel structure of the color filter, may be prepared in

## PROCESS

As shown in Figures 2, 5a and 5b, the outer surface of the thermally imageable layer (12) of the donor element (10) is brought into close proximity with the image receiving layer (24) of the receiving element (20) to form the assemblage (25). Vacuum and/or pressure can be used to hold the donor element (10) and the receiver element (20) together to form the assemblage (25). As another alternative, the donor element (10) and receiver element (20) can be taped together and taped to the imaging apparatus. A pin/clamping system can also be used. Alternatively, the surface of the donor element and or the receiver element may be roughened during coating by laminating a matte polyethylene coversheet. This serves improve the average uniformity of the contact between the donor element (10) and the receiver element (20), by facilitating the evacuation of air from between the donor element (10) and the receiver element (20).

The assemblage (25) is then exposed through the donor element (10) in selected areas by radiation (L) in the form of heat or light. As mentioned above, the exposure pattern is the desired pattern of the color filter. The optional heating layer (16) or the thermally imageable layer absorbs the radiation (L), generating heat which causes transfer of the heat-exposed portions of the thermally imageable layer (12) to the receiver element (20).

After exposure, the donor element (10) is separated from the receiver element (20). This may be done by peeling the two elements apart. Very little peel force is typically required; the donor support (10) may simply be separated from the receiver element (20). Any conventional manual or automatic separation technique may be used. Best quality imaging results are obtained when the process of separating the donor and receiver is performed with a consistent peel speed and radius of curvature with the direction of peeling oriented parallel to the color filter stripe pattern.

After separation of the donor element (10) and the receiver element (20), the color image is transferred to the receiver element, while the unexposed, unwanted portions of the thermally imageable layer (12) remain on the donor element,

The radiation (L) is typically provided by a laser. Laser radiation may be provided at a laser fluence of up to about 1 J/cm<sup>2</sup>, preferably

coating (34) may be a suitable polycarbonate, a polyurethane, a polyester, polyvinyl chloride, styrene/acrylonitrile copolymer, poly(caprolactone), vinylacetate copolymers with ethylene and/or vinyl chloride, (meth)acrylate homopolymers (such as butyl-methacrylate), copolymers, and mixtures thereof. Alternately, an image receiving layer similar to that described above, for the receiving element, may be applied to the permanent substrate, by laminating a separate receiving element to the permanent substrate and removing, e.g. peeling, the receiver support, prior to transferring the color image to the permanent substrate.

It is important that the surface of the substrate (30) adjacent the color image have greater adhesion to the color image (12') than the adhesion of the color image and image receiving layer to the receiver support. The substrate (30) may be any material that will support the subsequent layers and transmit light generated by LCD display. Some suitable materials include transparent plastic films, as described above, glass, and composites. Thin glass substrates are preferred. Glass as thin as 50 microns can be used. The upper limit on thickness is set by the weight and desired properties of the end product. The thickness is usually less than 5 millimeters. Typical values are from 0.5-1.0 mm.

Preferably, the color image (12') is transferred to the substrate (30) by lamination. Nip or press lamination may be used, as is known in the art. A roll-to-roll HRL-24 Laminator, manufactured by DuPont, Wilmington, DE, is typically used to accomplish the lamination. The minimum useful pressure is about 210 kPa. The maximum pressure is determined by the pressure at which unwanted contamination, such as a speck of dust, can cause the substrate to crack. Generally the pressure should be less than about 69 MPa. After separation of the donor element (10) from the substrate (30), the color image (12') is transferred to the substrate to form a color filter element (35).

The next step in the process of the invention is to apply a planarization layer (40) to the so formed color filter.

The planarization layer (40) may be applied using any conventional coating technique. Such techniques are well known in the art and include spin coating, casting, gravure printing, and extrusion coating processes. The planarization layer can also be applied as a preformed film and laminated to the color filter element (35) as shown in Figure 8, wherein a stack comprising a rigid plate (61) such as a stainless steel plate; a

EXAMPLES

These non-limiting examples demonstrate the processes and products claimed and described herein. All temperatures throughout the specification are in°C (degrees Centigrade) and all percentages are weight percentages unless indicated otherwise. Sigma-Aldrich, St. Louis, MO, is a useful source of many of the materials used here.

Glossary:

- |    |                                      |   |
|----|--------------------------------------|---|
| 10 | NIR-1                                | 2-[2-[2-Chloro-3[2-(1,3-dihydro-1,1dimethyl-3-(4dimethyl-3(4sulfobutyl)-2H-benz[e]indol-2-ylidene)ethylidene]-1-cyclohexen-1-yl]ethenyl]-1,1-dimethyl-3-(sulfobutyl)-1H-benz[e]indolium, inner salt, (H.W. Sands Corp., Jupiter, FL)  |
| 15 | FSA                                  | Zonyl® FSA fluoro surfactant; 25% solids in water and isopropanol, [CAS No. 57534-45-7] A lithium carboxylate anionic fluorosurfactant having the following structure: $R_fCH_2CH_2SCH_2CH_2CO_2Li$ where $R_f = F(CF_2CF_2)_x$ and where $x = 1$ to 9 (DuPont, Wilmington, DE) |
| 20 | PEG 300                              | Polyethylene glycol 300 [CAS No. 25322-68-3], 100%, Scientific Polymer Products, Inc., Ontario, NY)   |
| 25 | Melinex® 573                         | 102 micron clear PET base (DuPontTeijinFilms™, a joint venture of E.I. du Pont de Nemours & Company)  |
|    | Creo Model 3244 Spectrum Trendsetter | Creo Inc., Vancouver, Canada  |
| 30 | Wyko Model RST Plus Surface Profiler | Wyko Corp., Tucson, Arizona   |
|    | Corning 1737 display grade glass     | Corning Glass Company, Corning, NY  |
| 35 | VAZO® 67                             | DuPont, Wilmington, DE  |

Solids content was measured by putting about 5 grams of acrylic latex in a tared, 5-cm aluminum pan, which was placed in a 75°C vacuum oven at about 400 mm Hg vacuum for 1 to 2 days. Percent solids was calculated by dividing the final sample weight by the initial sample weight.

5 Coating weights were measured by cutting out and weighting a 1.dm<sup>2</sup> piece of film, removing the coating by rubbing with a paper towel moistened in either methanol or acetone, drying the film for several minutes, and reweighing. Coating weights are the difference in weights of the before and after film in mg, units: mg/dm<sup>2</sup>.

10 COLOR FILTER PREPARATION

RECEIVER LATEXES

PR-8

A 3-liter, round bottom flask was equipped with a condenser, addition funnel, initiating solution inlet port, mechanical stirrer, heater and  
15 temperature controller probe, with the contents maintained under a nitrogen atmosphere. The flask was charged with 700 grams of deionized water and 6.90 grams of POLYSTEP B-7. A first initiating solution of 0.40 grams ammonium persulfate dissolved in 100 mL of deionized water was prepared. A first monomer blend of 140.0 grams methyl  
20 methacrylate, 4.0 grams glycidyl methacrylate, and 50.0 grams n-butyl acrylate was prepared and placed in the addition funnel. A second monomer blend of 140.0 grams methyl methacrylate, 4.0 grams glycidyl methacrylate, 50.0 grams n-butyl acrylate, and 12.0 grams of methacrylic acid was prepared. While stirring, the contents of the reaction flask were  
25 heated to 85°C and maintained at that temperature, within a range of 3°C, through the following steps.

The synthesis of the acrylic latex was initiated by the first addition to the flask of 80 mL of the first initiating solution, followed within one minute by the second addition of 20 mL of the first monomer blend from the  
30 addition funnel. These two additions were complete in less than one minute. The remaining portion of first monomer blend in the addition funnel was added to the flask, beginning within two minutes, at a constant rate over a period of 60 minutes. At the end of the addition of the first monomer blend, the second monomer blend was promptly added within  
35 two minutes to the addition funnel and immediately thereafter was added to the flask at a constant rate over a period of 60 minutes total. When the addition of the second monomer blend was complete, the remaining

30 minutes after the completion of the addition of the initiating solution. Thereafter the contents of the reaction flask were cooled to ambient temperature, and filtered through a fine paint strainer, (Paul N. Gardner Company, Inc. Pompano Beach, FL, Item number ST-F 60 x 48 mesh) to provide the acrylic latex PR-9.

The acrylic latex had a particle size of 94 nm, 33.4% solids, and a T<sub>g</sub> of 39°C.

#### RECEIVER FILM

A receiver film (FR-1) was prepared as follows. A coating composition was prepared in a 40-Liter stainless steel vessel with the following ingredients: 3241.69 grams of deionized water, 144.08 grams of Zonyl® FSA, 2161.13 grams of Butyl Cellosolve, 9148.78 grams of PR-8, and 21323.13 grams of PR-9, added to the vessel in the stated order. The composition was coated to a dry coating weight of 13.1 mg/dm<sup>2</sup> on a supporting base. The coating composition was coated on the Elvax® 550 surface of a supporting base of 64 micron thick Elvax® 550 (ethylene vinyl acetate copolymer, DuPont) coated onto 102 micron thick Cronar® 471X polyester (DuPont, Wilmington, DE). The coated supporting base was dried at temperatures which increased from an initial value of about 38°C to a final value of about 65°C over a period of about 5 minutes. After the film was dried, it was interleaved with OSM matte polyethylene film (Tredegar Co., New Bern, NC) and run at ambient temperature through nip rolls at 650 kPa to emboss the polyethylene pattern onto the receiver surface. The polyethylene film was left on the receiver surface until just prior to imaging to prevent contamination of the coated surface during subsequent handling.

#### DONOR ELEMENT

##### DISPERSING RESIN DR-3

Pigment dispersant DR-3 was prepared by the cobalt chain transfer graft copolymer methods as described in US Patent 5,231,131, Chu, et. al. The composition is listed in Table 1. The composition before the -g- was polymerized by cobalt chain transfer polymerization to an oligomer with a polymerizable group at the end. This oligomer was then copolymerized with the remaining monomer mixture to form a graft copolymer.

nitrogen atmosphere. The flask was charged with 700 grams of deionized water and 6.90 grams of POLYSTEP B-7. A first initiating solution of 0.40 grams ammonium persulfate dissolved in 100 mL of deionized water was prepared. A first monomer blend of 90.0 grams methyl methacrylate, 4.0 grams glycidyl methacrylate, and 100.0 grams n-butyl acrylate was prepared and placed in the addition funnel. A second monomer blend of 90.0 grams methyl methacrylate, 4.0 grams glycidyl methacrylate, 100.0 grams n-butyl acrylate, and 12.0 grams of methacrylic acid was prepared. While stirring, the contents of the reaction flask were heated to 85°C and maintained at that temperature, within a range of 3°C, through the following steps.

The synthesis of the acrylic latex was initiated by the first addition to the flask of 80 mL of the first initiating solution, followed within one minute by the second addition of 20 mL of the first monomer blend from the addition funnel. These two additions were complete in less than one minute. The remaining portion of first monomer blend in the addition funnel was added to the flask, beginning within two minutes, at a constant rate over a period of 60 minutes. At the end of the addition of the first monomer blend, the second monomer blend was promptly added within two minutes to the addition funnel and immediately thereafter was added to the flask at a constant rate over a period of 60 minutes total. When the addition of the second monomer blend was complete, the remaining initiating solution was promptly added in less than one minute. Stirring of the contents of the flask at 85°C plus or minus 3°C was maintained for 30 minutes after the completion of the addition of the initiating solution. Thereafter the contents of the reaction flask were cooled to ambient temperature and filtered through a fine paint strainer, (Paul N. Gardner Company, Inc. Pompano Beach, FL, Item number ST-F 60 x 48 mesh) to provide the acrylic latex PR-5.

The acrylic latex had a particle size of 81nm, 33.3% solids, and a Tg of 113°C.

#### PR-6

A 3-liter, round bottom flask was equipped with a condenser, addition funnel, initiating solution inlet port, mechanical stirrer, heater and temperature controller probe, with the contents maintained under a nitrogen atmosphere. The flask was charged with 700 grams of deionized water and 6.90 grams of POLYSTEP B-7. A first initiating solution of



Table 3. Gram Weights of Ingredients for Color Filter Donor Coating.

Ingredient	Red	Green	Blue	Black
Deionized Water	3942.00	4032.00	3960.00	3882.60
Zonyl® FSA	14.40	34.20	14.40	43.20
PR-5	2754.00	2538.00	2448.00	2754.00
PR-6	302.40	446.40	613.80	446.40
DMEA, 10% in water	109.80	106.20	109.80	109.80
PEG-300		54.00		
NIR-1	54.00	39.60	54.00	
PD-R5	10818.00			
PD-G4		10764.00		
PD-B2			10800.00	
PD-K1				10764.00

### IMAGING

5           Color donors were imaged on the Trendsetter® in the order R, B, G, K directly onto the receiver sheet. The power settings (Wpower, watts) were: R = 6.35, B=7.20, G=5.45, K=5.90. The drum speeds (rpm) were: R=108, B=120, G=110, K=120.

10           The image used for preparation of the color filter was composed of alternating R/G/B stripes with widths of 110 microns. The stripes were separated by gaps of 10 microns. A black grid was overprinted on the color stripes; the width of the black lines was 30 microns and hence a 10-micron portion of the black grid overlapped each color stripe on either side of the gap between stripes. The black grid had a pitch of 200 microns  
15           in the direction orthogonal to the color stripes. Each color filter image was 13 cm square, and there were twelve images per receiver sheet.

### LAMINATION OF FILTER TO GLASS

#### Glass Preparation

20           Pieces of Corning 1737 display grade glass (18 cm square) were rinsed with deionized water, rinsed and gently scrubbed with soapy water (Micro® brand cleaner), rinsed with deionized water, rinsed with isopropanol, rinsed with deionized water, and then dried vertically in a stream of dry nitrogen at room temperature.

glass samples with a spin coater at 1000 rpm. The coated glass was dried at room temperature for 24 hours. The thickness of the adhesive coating was 150 nm. Thickness was measured by scratching a small area to bare glass and measuring thickness with the Wyko. The individual color filters  
5 were laminated to the adhesive-coated glass samples in a Tetrahedron Model MTP13 laminator at 80°C for three minutes and 7 megapascals pressure. The laminated color filters were allowed to cool to room temperature and then the backing film was peeled off.

#### PLANARIZER FILM PREPARATION

##### 10 CHAIN TRANSFER AGENT SOLUTION, CTA-1

A chain transfer agent solution used in the following acrylic latex synthesis was prepared as described by the methods of U.S. Patent 5,362,826, Berge, et. al. and U.S. Patent 5,324,879, Hawthorne.

A 500-liter reactor was equipped with a reflux condenser and  
15 nitrogen atmosphere. The reactor was charged with methyl ethyl ketone (42.5 kg) and isopropyl-bis(borondifluorodimethylglyoximate) cobaltate (III) (Co III DMG) (104 g) and the contents brought to reflux. A first mixture of Co III DMG (26.0 g), methyl methacrylate (260 kg), and methyl ethyl ketone (10.6 kg) was added in a first feed to the reactor at a constant rate  
20 over a total period of 4 hours. Starting at the same time as the start of the first feed, a second mixture of VAZO® 67 (5.21 kg) and methyl ethyl ketone (53.1 kg) was added in a second feed to the reactor at a constant rate over a total period of 5 hours. After the completion of the second feed in 5 hours, the reactor contents were kept at reflux for a further  
25 30 minutes. After cooling to ambient temperature, a 70 wt % solids solution of the chain transfer agent, CTA-1, was obtained.

#### PR-1

An acrylic latex of controlled molecular weight polymer resin was prepared as detailed below using the chain transfer agent solution  
30 according to the method in US Patent 5,773,534, Antonelli, et. al.

A 3-liter, round bottom flask was equipped with a condenser, addition funnel, initiating solution inlet port, mechanical stirrer, heater and temperature controller probe, with the contents maintained under a nitrogen atmosphere. The flask was charged with 700 grams of deionized  
35 water and 6.90 grams of POLYSTEP B-7. A first initiating solution of 0.40 grams ammonium persulfate dissolved in 100 mL of deionized water was prepared. A first monomer blend of 122 grams methyl methacrylate,

was prepared. A first monomer blend of 126.0 grams methyl methacrylate, 4.0 grams glycidyl methacrylate, 60.0 grams n-butyl acrylate and 4.0 grams chain transfer agent solution was prepared and placed in the addition funnel. A second monomer blend of 126.0 grams methyl methacrylate, 4.0 grams glycidyl methacrylate, 60 grams n-butyl acrylate, 12.0 grams of methacrylic acid and 4.0 grams chain transfer agent solution was prepared. While stirring, the contents of the reaction flask were heated to 85°C and maintained at that temperature, within a range of 3°C, through the following steps.

The synthesis of the acrylic latex was initiated by the first addition to the flask of 80 mL of the first initiating solution, followed within one minute by the second addition of 20 mL of the first monomer blend from the addition funnel. These two additions were complete in less than one minute. The remaining portion of first monomer blend in the addition funnel was added to the flask, beginning within two minutes, at a constant rate over a period of 60 minutes. At the end of the addition of the first monomer blend, the second monomer blend was promptly added within two minutes to the addition funnel and immediately thereafter was added to the flask at a constant rate over a period of 60 minutes total. When the addition of the second monomer blend was complete, the remaining initiating solution was promptly added in less than one minute. Stirring of the contents of the flask at 85°C plus or minus 3°C was maintained for 30 minutes after the completion of the addition of the initiating solution. Thereafter the contents of the reaction flask were cooled to ambient temperature and filtered through a fine paint strainer, (Paul N. Gardner Company, Inc. Pompano Beach, FL, Item number ST-F 60 x 48 mesh) to provide the acrylic latex, PR-10.

Properties of this latex are summarized in Table 3.

#### PR-11

An acrylic latex E99339-71 of controlled molecular weight polymer resin was prepared as detailed below using the chain transfer agent solution according to the method in US Patent 5,773,534, Antonelli, et. al.

A 3-liter, round bottom flask was equipped with a condenser, addition funnel, initiating solution inlet port, mechanical stirrer, heater and temperature controller probe, with the contents maintained under a nitrogen atmosphere. The flask was charged with 700 grams of deionized water and 6.90 grams of POLYSTEP B-7. A first initiating solution of

### LAMINATION OF PLANARIZER

Each of the three planarizing latexes was coated onto Melinex® 574 (DuPont) at four thicknesses as follows: A coating composition was prepared from each planarizing latex by mixing, in order, 4.50 grams of latex, 4.76 grams of water, 0.70 grams of butyl cellosolve, and 0.040 grams of Zonyl® FSA. Each coating composition was then coated onto four pieces of Melinex® 574 with #6, #8, #10, and #13 Meyer rods. The coated films were then air dried at ambient temperature for at least 24 hours before use. Thicknesses of the #6, #8, #10, and #13 rod coatings were determined to be 1.46, 2.07, 2.41, and 3.36 microns, respectively. Thicknesses of the planarizer layers were measured by laminating some of the film to a microscope slide, pretreated with an adhesive layer, scratching the resulting film to bare glass, and measuring thickness on Wyko Model RST Plus Surface Profiler (Wyko Corp., Tucson, Arizona).

The planarizing films were then each placed coated side down on a color filter on glass and then laminated in the Tetrahedron press laminator at 130°C for three minutes at 14 megapascals pressure. The planarized color filters were then cooled to room temperature before the Melinex® was peeled off. The planarized color filters were then annealed in a vacuum oven at 150°C for 90 minutes.

### SURFACE ROUGHNESS MEASUREMENTS

#### WYKO MEASUREMENTS

The roughness of the samples was measured with the Wyko optical profilometer. The root-mean-square (RMS) roughness, Rq (nm), was measured at five locations on each sample: center, left and right edges, and left and right bottom corners. The results were then averaged, and are summarized in Table 5.

Table 5 RMS surface roughness (Rq, nm) for planarized samples

Coating Rod	Thickness	PR-1	PR-10	PR-11
#6	1.46	134	151	165
#8	2.07	122	153	189
#10	2.41	65	145	171
#13	3.36	53	114	-

image on the image receiving layer of the receiver element;

- 5 (3) optionally applying the colorant-containing image on the image receiving layer of the receiver element to a permanent substrate, and removing the receiver support to transfer the colorant-containing image on the image receiving layer to the permanent substrate, and
- 10 (4) applying a planarizing element comprising a support and a planarizing layer to the image receiving layer, and removing the support, wherein the planarizing layer is adjacent the colorant-containing image, and wherein the planarizing layer comprises a crosslinkable binder having a weight average molecular weight of about 20,000 to about 110,000.
- 15 8. The method of Claim 7 wherein the crosslinkable binder has a weight average molecular weight of about 30,000 to about 100,000.
9. The method of Claim 8 wherein the crosslinkable binder has a weight average molecular weight of 50,000 to about 85,000.
- 20 10. The method of Claim 7 wherein the thermally imageable layer, image receiving layer or both comprise a crosslinkable binder having a number average molecular weight of about 1,500 to about 70,000.
11. The method for making a color image of Claim 7 wherein step (3) is optional, and the receiver support is a transparent material.
- 25 12. The method for making a color image of Claim 7 wherein permanent substrate is a transparent material.
13. The method for making a color image of Claim 11 or 12 wherein transparent material is glass.
14. The method for making a color image of Claim 11 or 12 wherein transparent material is treated glass.
- 30 15. The method for making a color image of Claim 11 or 12 wherein the transparent material is a rigid plastic,
16. The method for making a color image of Claim 15 wherein the rigid plastic is polycarbonate.
- 35 17. The method for making a color image of Claim 7 wherein the crosslinkable binder is a polymer prepared by emulsion polymerization or solution polymerization.

27. The method for making a color image of Claim 26 wherein the rigid plastic is polycarbonate.

28. A liquid crystal display comprising a color filter, wherein the color filter is prepared using a thermal imaging process, and a planarizing element comprising a planarizing layer having a crosslinkable binder, having a weight average molecular weight of about 20,000 to about 110,000.

29. The liquid crystal display of Claim 28 wherein the crosslinkable binder has a weight average molecular weight of about 30,000 to about 100,000.

30. The liquid crystal display of Claim 29 wherein the crosslinkable binder has a weight average molecular weight of 50,000 to about 85,000.

31. The liquid crystal display of Claim 28 comprising a color filter having a glass substrate.

32. The liquid crystal display of Claim 31 wherein the glass substrate has a black matrix thereon.

33. The liquid crystal display of Claim 32 comprising a color filter having at least three color images thereon.

34. The liquid crystal display of Claim 33 wherein the color images are red, blue and green.

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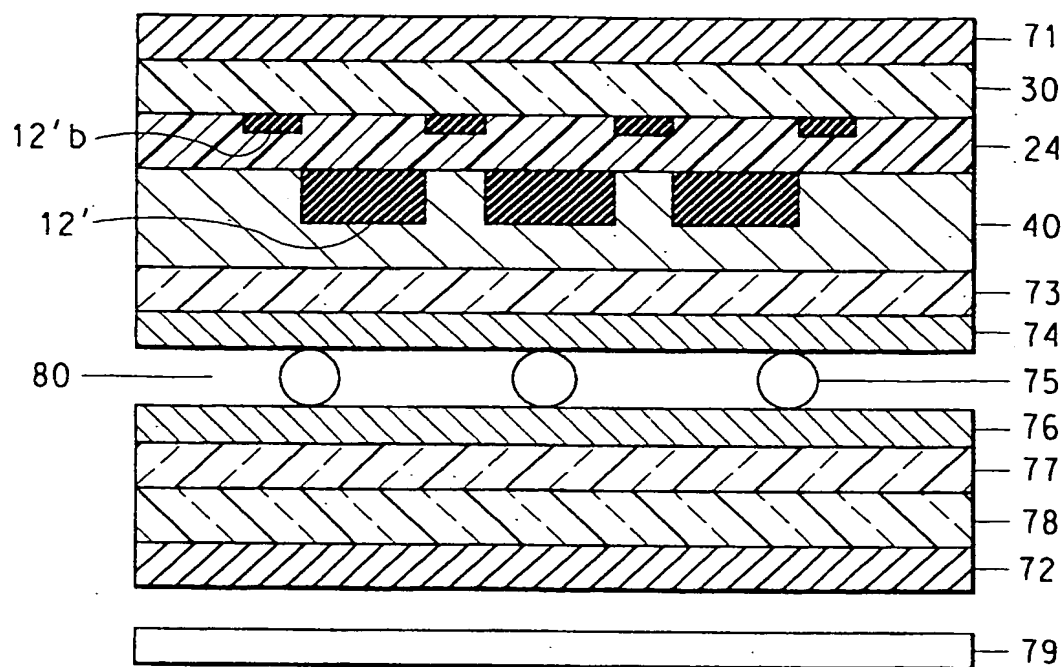


FIG. 1

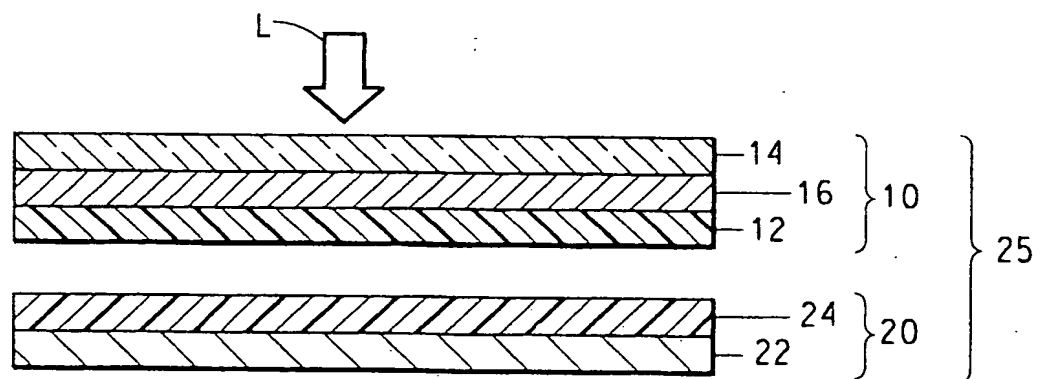


FIG. 2

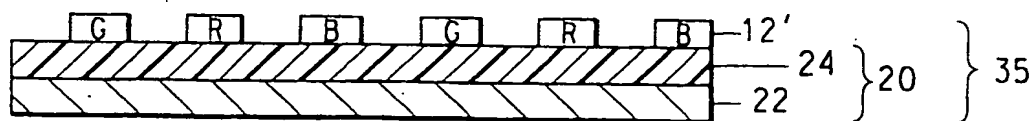


FIG. 3

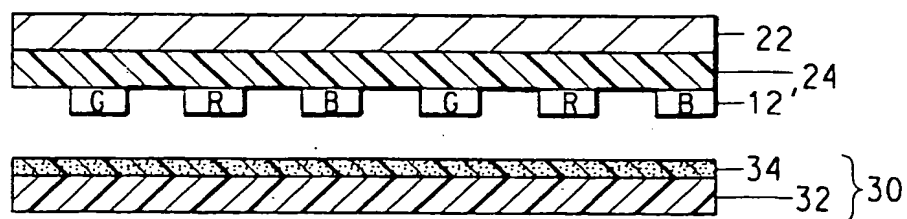


FIG. 4

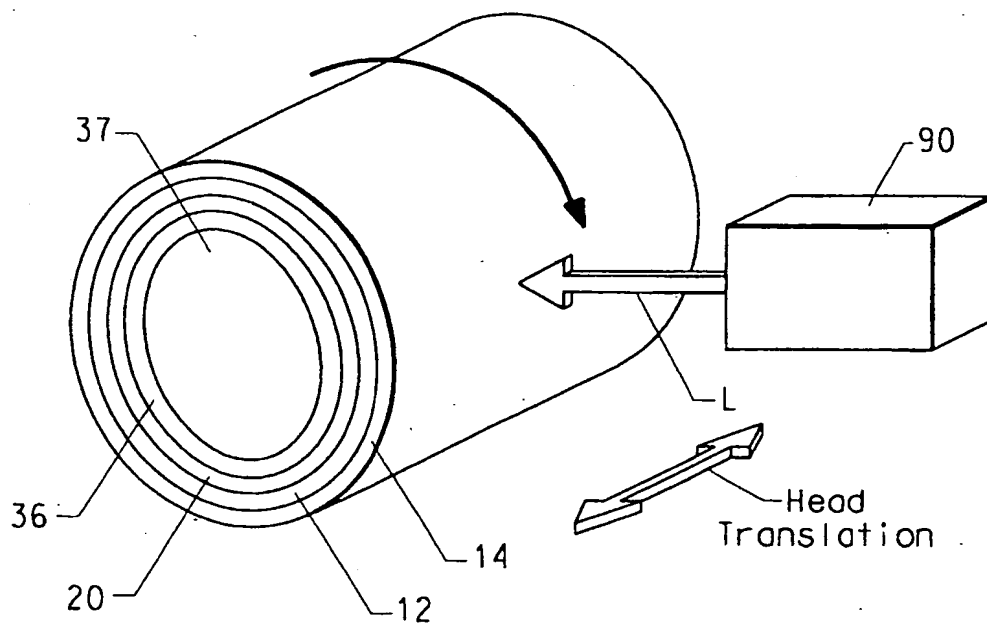


FIG. 5A



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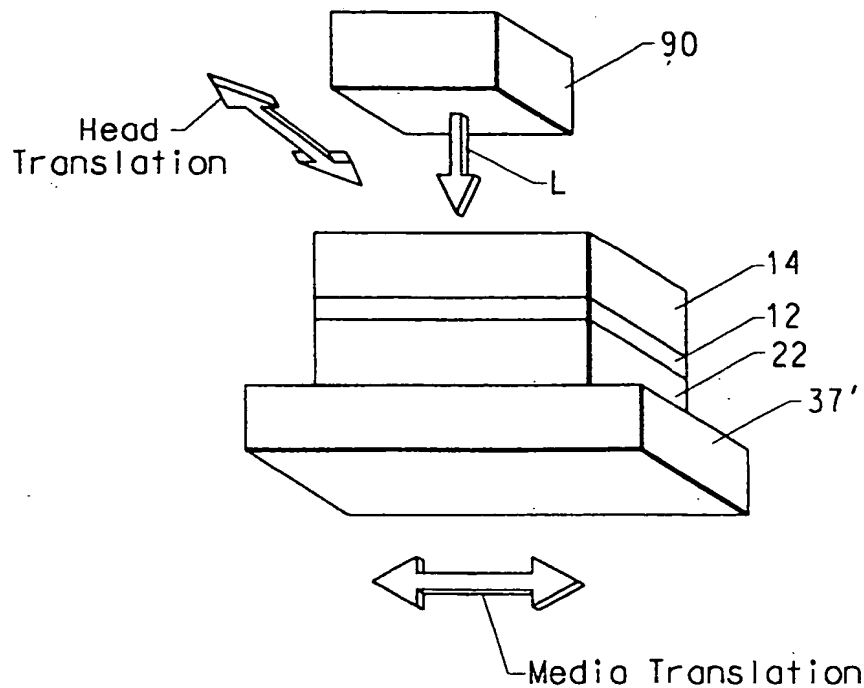


FIG. 5B

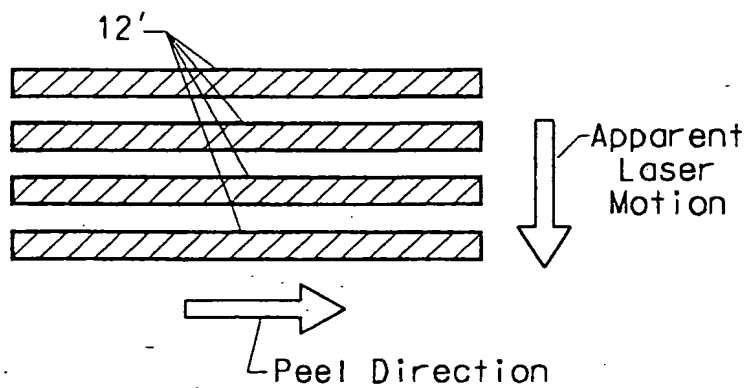


FIG. 6

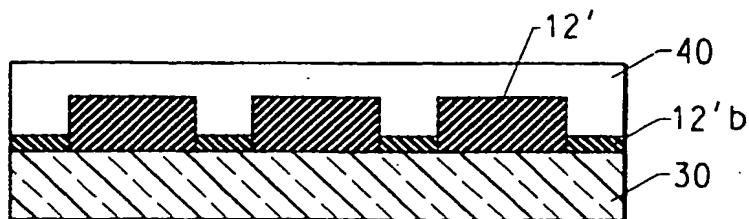


FIG. 7

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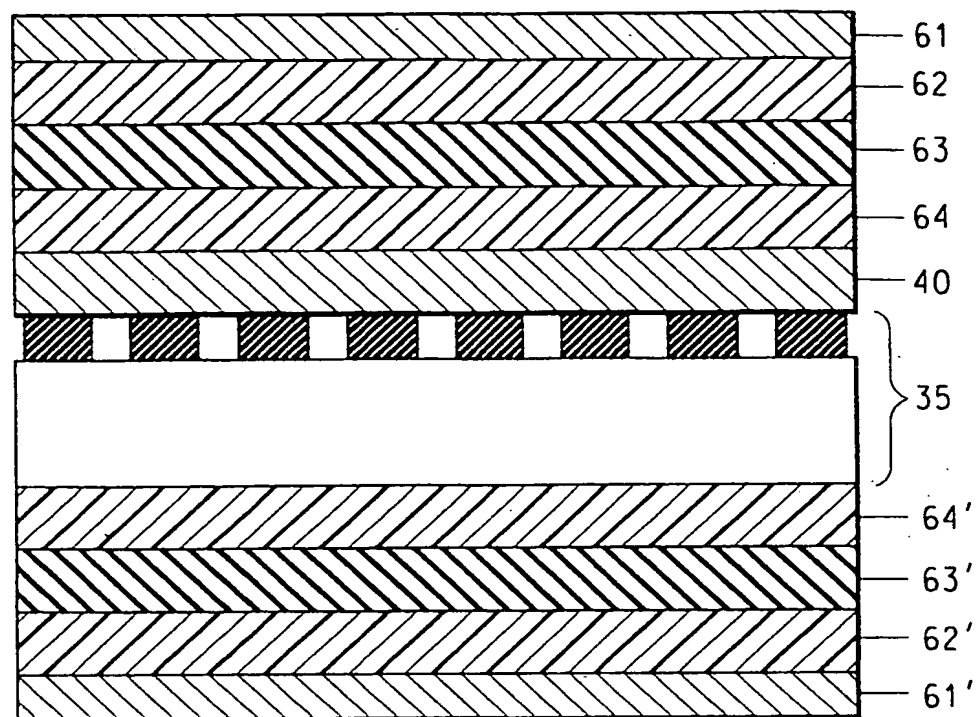


FIG. 8

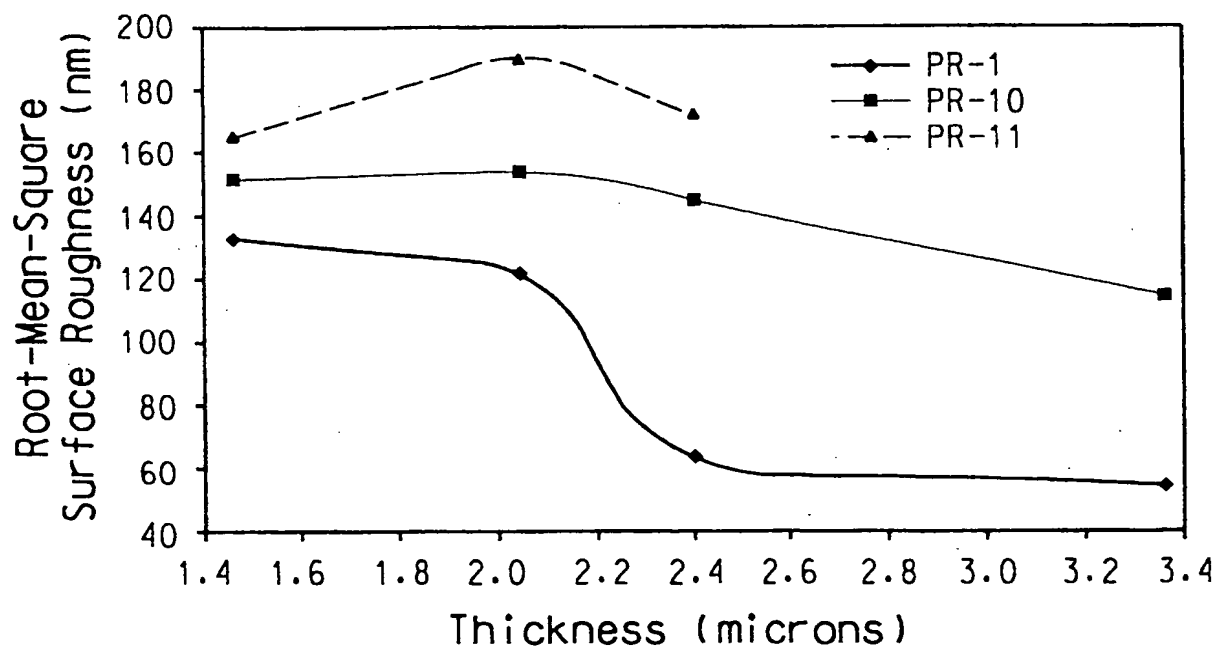


FIG. 9

## INTERNATIONAL SEARCH REPORT

Internat Application No  
PCT/US 03/02060

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B41M5/40 B41M7/00 B41M5/26 G02B5/20

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B41M G02B C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 540 147 A (JOHNSON RONALD E) 30 July 1996 (1996-07-30) column 1, line 65 - line 67 column 2, line 44 - line 60 column 4, line 44 - line 45 --- -/--	1-34

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

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Date of the actual completion of the international search

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(81) Designated States (national): JP, KR, US.

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Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: PLANARIZING ELEMENT FOR THERMAL PRINTING OF COLOR FILTER

(57) Abstract: A planarizing element is described for use in a thermal imaging process. The planarizing element includes a support; a planarizing layer comprising a crosslinkable binder having a weight average molecular weight of about 20,000 to about 110,000.



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